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Description of developmental stages of *Phyllognathus dionysius* Fabricius, 1792 (Insecta, Coleoptera, Scarabaeidae) with notes on biology from central India

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Abstract

Detailed description of the 3rd instar larva and pupa of *Phyllognathus dionysius* is described along with notes on biology and distribution. Some beetles belonging to the family Scarabaeidae are economically important as crop pests. Grubs of *P. dionysius* are coprophagus and polyphagous and known to feed on roots of jowar (*Sorguhm bicolor*), bajra (*Pennisetum glaucum*), maize (*Zea mays*), turmeric (*Curcuma longa*), sugarcane (*Saccharum officinarum*) and paddy (*Oryza sativa*) while adults are nocturnal in habit and feed on foliage of *Ficus* sp. For this study, grubs of *P. dionysius* were collected from the Bor forest of Maharashtra, central India. Collected grubs were reared in rearing pots in the laboratory under optimum temperature and humidity. Our knowledge of developmental stages of scarabs lags behind our knowledge of the adults especially in the fields of morphology and taxonomy. In this study, we provide brief diagnostic characters for identification of the immature stages of *P. dionysius* along with the biology. Life cycle of *P. dionysius* was completed in 145–163 days with prepupal period of 24–36 hours and pupal period of 9–11 days.

Key Words

Coprophagy, Dynastinae, early stages, morphology, rhinoceros beetle, scarabs

Introduction

Phyllognathus dionysius belongs to the subfamily Dynastinae (rhinoceros beetles) of family Scarabaeidae (scarab beetles). Dynastines are famous for their remarkably large size amongst scarabs. Burmeister (1847) and Endrodi (1985) published the earliest records of the Dynastinae of the world. Arrow (1910) described Dynastinae of the Indian subcontinent listing 30 species out of 14 genera. After Arrow, various authors contributed to the Dynastinae fauna of India from different states of India, Orissa (Biswas and Chatterjee 1991), from Madhya Pradesh (Chandra 2000), Sikkim (Chatterjee and Biswas 2003), Tamil Nadu (Chandra 2009), Uttarakhand (Chatterhee 2010). *P. dionysius* is an oriental species predominantly found in India (Andhra Pradesh, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Odisha, Uttar Pradesh, West Bengal, Maharashtra, Sri Lanka, Myanmar) but also known from Vietnam and reaching the Palaearctic region (Nepal, Pakistan).

This species is commonly found in central Indian province. It is recorded from Melghat Tiger Reserve, Maharashtra (Thakare et al. 2012) and Madhya Pradesh (Chandra and Gupta 2013), Achankamar Amarkantak Biosphere reserve, Veerangana Durgawati Wildlife Sanctuary (Chandra and Gupta 2011; Chandra and Gupta 2012).

Grubs of *P. dionysius* are coprophagus and polyphagous and known to feed on roots of jowar (*Sorguhm bicolor*), bajra (*Pennisetum glaucum*), maize (*Zea mays*), turmeric (*Curcuma longa*), sugarcane (*Saccharum officinarum*), paddy (*Oryza sativa*), potato, garden palm trees, apple, pear and apricot while adults are nocturnal in habit

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and feed on foliage of *Ficus* sp. (Bhatnagar 1971; Kumar et al. 2005; Bhawane et al. 2012; AINPWB 2018).

The immature stages, biology and lifecycle of *Phyllognathus dionysius* from Indian subcontinent is poorly known. Our knowledge of developmental stages of scarabs lags behind our knowledge of the adults, especially in the fields of morphology and taxonomy (Hayes 1929). Arrow (1910) mentioned the immature stages of this species and Beeson (1941) gave short note on its biology but, the detailed description of immature stages is lacking. Hence an attempt has been made to describe the 3rd instar larva and pupa of *P. dionysius* along with notes on its biology.

Methods

Grubs of *P. dionysius* were collected from dung pads on open grounds of Zilpi village located at 21°06.58'N, 78°86.66'E and situated around 35 km from Nagpur district of Maharashtra, India. The collection site is adjacent to a lush flora and fauna of the Bor Tiger Reserve. Collected grubs were reared in glassy rearing pots in the laboratory under optimum temperature and humidity (27 °C ± 2 °C with RH 65 to 75%). These were filled with soil and dung cakes. Potato tubers were grown in the rearing pots. Water was sprinkled on upper surface of rearing pots every alternate day to maintain the moisture content. Dung cakes were added in the rearing pots every 7 days to ensure adequate food supply. Temperature was maintained in the laboratory with the help of coolers and heaters.

For larval preservation methodology by Ritcher (1967) is used. Larvae were dipped in near boiling water for about 3 minutes and preserved in 70% alcohol or glycerol to prevent them from shrinking. Five specimens of 3rd instar grubs and five pupae were taken for taxonomic studies, photographed and described. The terminology follows Ritcher (1967). For the reliable identification of the 3rd instar larva, characters such as, head capsule, cranium, frons, clypeus, labrum, epipharynx, mandibles, antennae, thorax, legs, spiracles, number of setae on dorsum so as raster pattern on last abdominal segment were found to be significant for species identification. The distinguishing character of Dynastinae pupae is the presence of 'gin traps'.

The studied material is deposited in the entomology section of the Centre for Sericulture and Biological pest management and Research Laboratory (**CSBR**) of the RTM Nagpur University.

Results and discussion

Notes on their biology have been described earlier by Beeson (1941) from cold climates of North India and recently by Pathania (2014) from Himachal Pradesh. In our study from central India, adults were active from May onwards and lay their eggs after mating (Fig. 1A, B). Larvae are active from June to September. The developing larvae build individual, oval cells in the dung pats for feedin (Fig. 1C, D). Mating occurred mostly during the morning hours. The mating period lasted 6 to 8 minutes and the same pair tried to mate multiple times a day. A similar mating period is recorded for the flower chafer, *Protaetia aurichalcea* (Gujarathi and Pejaver 2014). An adult male tried to mate with other females in the captivity soon after earlier mating was completed. After mating the female tried to bury herself into the soil.

The life cycle of *P. dionysius* is completed in 145–163 days, with a prepupal period of 24 hours and a pupal period of 9 to 11 days (Table 1).

Table 1. Duration of various developmental stages of *P. dionysius*.

Sr No	Developmental stage	*n*	Range of duration (in days)
1	egg	8	8–10
2	1st instar	7	11–16
3	2nd instar	7	23–27
4	3rd instar	35	92–98
5	prepupal stage	31	24–36 hours
6	pupa	27	9–11

Description of 3rd instar larva and pupa of *Phyllognathus dionysius*

***Phyllognathus dionysius* Fabricius, 1792**

3rd instar larva – Length 42 mm, width 10 mm.

Width of the head capsule 6.46 mm, length of the head capsule 7.22 mm, *Cranium* dark red brown, the surface with a deep, regular punctations. Frons with a pair of posterior frontal setae, 2 anterior angle frontal setae on each side so as anterior frontal setae absent. Remaining cranial surface with 2 long dorso epicranial setae on each side, 1 long epicranial seta on each side and 7 to 10 paraocellar setae on each side. Clypeus somewhat rectangular, dark reddish brown in appearance, with irregular deep punctations with 2 pairs of long lateral setae on each side (Fig. 2A). Labrum irregular in shape, dark reddish brown, with irregular deep punctations. 9 to 11 anterior setae, 5 to 7 posterior setae and 3 to 5 lateral setae on each side. Epipharynx asymmetrical. Chaetoparia with 55 to 65 setae on each side (Fig. 2C). Maxillary stridulatory area is with a row of 8 wide, oval teeths (Fig. 2E). Apical uncus of galea strong, wide at base and pointed towards the end. Apex of lacinia bears 3 unci fused at the base (Fig. 2D). Left mandible with 3 scissorial teeth anterior to scissorial notch and 1 scissorial tooth posterior to notch. Molar area with 2 lobes. Lateral edge with 5 setae (Fig. 2G). Right mandible with 3 scissorial teeth, the third tooth smaller. Molar area with 3 lobes. Lateral edge with 7

Figure 1. *Phyllognathus dionysius* adults and larva. **A.** Male and female; **B.** Male and female during mating; **C.** 3rd instar larvae; **D.** Larvae in individual oval cells.

setae (Fig. 2F). Stridulatory area of each mandible is well marked by 27 to 30 fine striae (Fig. 2H). Antenna surface on last segment with 6 dorsal and 6 ventral sensory spots (Fig. 2B). Thorax with a 'C'-shaped thoracic spiracle, 0.7 mm in width and 0.8 mm in length. Tarsal claws similar on all legs bearing 1 basal thick and one lateral long seta (Fig. 3E). Three thoracic segments with a single transverse row of 8–10 setae. Ventrally each thoracic segment bears a single row of 25 to 30 setae arranged irregularly. Abdominal spiracles I to IV similar in size while the spiracles on segments V to VIII get progressively smaller. Spiracles are surrounded by long setae (Fig. 3B). Dorsa of segments I to VI with long and short setae irregularly arranged. Dorsa of 7th abdominal segment with 1 lower transverse row of 17–20 setae and 1 upper irregular row of 25–30 setae. Dorsa of 7th abdominal segment with 2 transverse rows of 18–20 setae. Dorsa of 9th segment with 2 transverse rows of 7–8 setae. Ventrally, segments I to VII with a single transverse row of 25–30 setae. Segment VIII – IX with 6–8 setae arranged transversely. Raster with lower and upper anal lobe with 55–60 setae respectively (Fig. 3C).

Prepupa – The prepupal stage lasts for 24 to 36 hours. After this period the grub becomes inactive. Transparent integument of 3rd instar larva is replaced by a dirty white appearance with a shrunken body. The prepupal stage larva, compared to other mature III instar larva, is found to bury itself deep inside the soil towards the bottom of the rearing chamber (Fig. 4A).

Pupa – Pupa exarate. The male pupa is elongated, oval, 25 mm in length and 12 mm in width (Fig. 4B, D). The frontoclypeus with a dorsal, broad hornlike structure slightly bent upwards. The antennae, mandibles so as palpi are distinct. The fore, mid and hindlegs are distinct. The abdomen is 9 segmented (Fig. 4C). The spiracles on segment I are hidden, the spiracles on segment II to IV are elongated and sclerotised (Fig. 5D). The tergal segments I to V bear 5 pairs of dioneiform organs or "gin traps" (Fig. 5B). Tergum VIII with two lateral, ovate depressions. 9th tergal segment with two triangular folds, tapering towards the end (Fig. 5C). The female pupa is stout, oval, without a horn, 22 mm in length and 14 mm wide. The female pupa is shorter and wider than the male pupa. The body is wooden brown in coloration, without horn. The other characters are similar to the male pupa (Fig. 4B).

During our study, the life cycle of *P. dionysius* was completed in 145 to 163 days, with a prepupal period of 24–36 hours and a pupal period of 9 to 11 days. This period is in average shorter than the one recorded by Pathania (2014) of 162.4 days, reported from a hilly region and colder temperatures from Himachal Pradesh. This suggest that the weather conditions play an important role in duration of life cycle of this species. *P. dionysius* completes its life cycle faster in warmer weather and plains of central India than in colder hills of Himachal Pradesh.

Considering the economic and ecological importance of white grubs, it is important to identify the larval and pupal stages of these beetles for better management strategies.

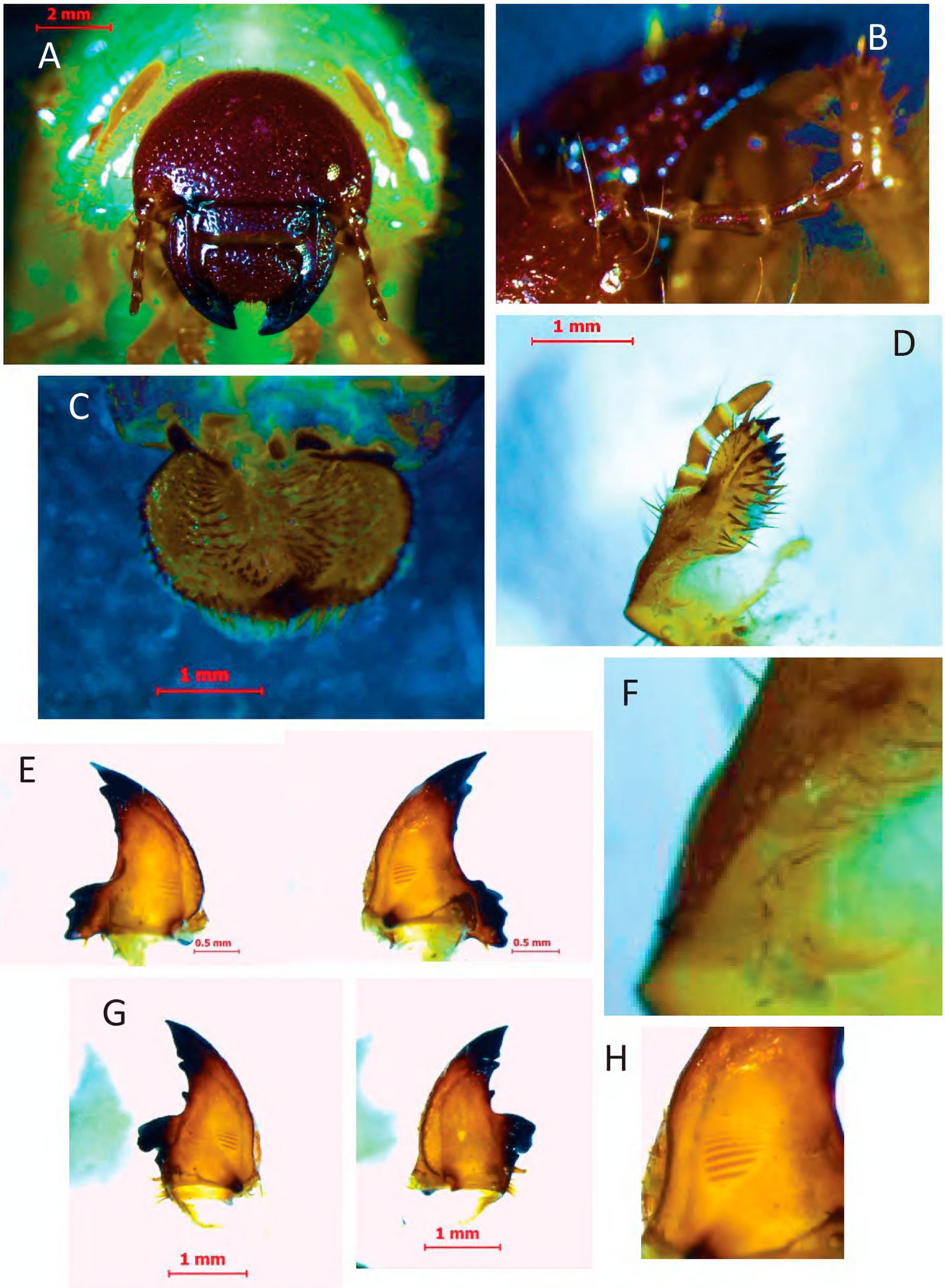

Figure 2. Mouth parts of 3rd instar larva of *Phyllognathus dionysius*: **A.** Head; **B.** Antenna; **C.** Hypopharynx; **D.** Maxilla; **E.** Right mandible; **F.** Maxillary teeth; **G.** Left mandible; **H.** Mandibular striations.

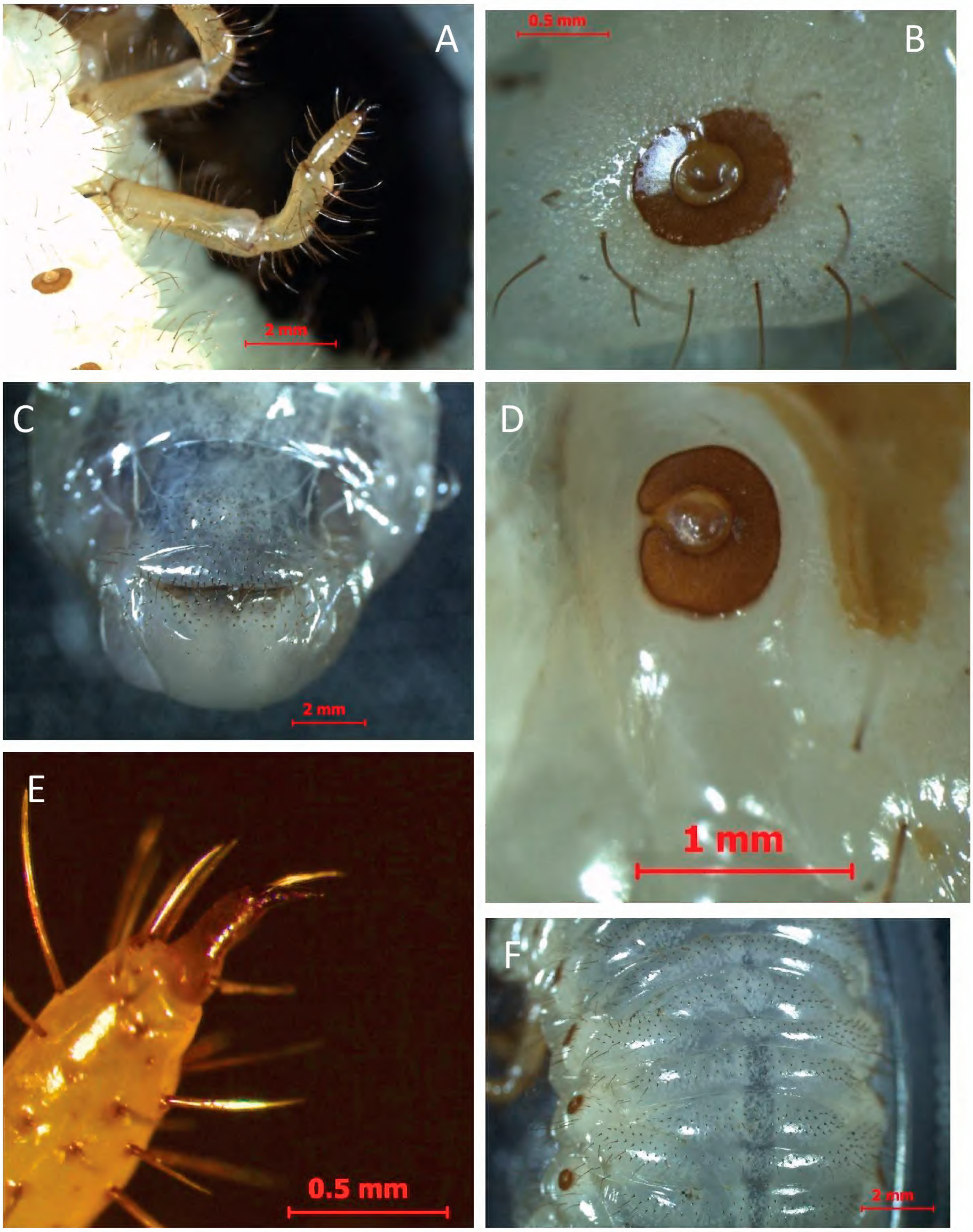

Figure 3. Morphological characters of 3rd instar larva of *Phyllognathus dionysius*: **A.** Legs; **B.** Abdominal spiracle; **C.** Anal slit; **D.** Thoracic spiracle; **E.** Tarsal claw; **F.** Abdominal segments.

Hence 3rd instar larval characters are described along with the description of the pupa. With this study an attempt has been made to describe the developmental stages and biology of *P. dionysius* from central Indian province.

Some adult ground beetles (Carabidae) were seen predating on *P. dionysius* larvae in the field. This suggest that they may act in controlling the grub population. Further studies in this regard are needed.

Figure 4. Morphological characters of prepupa and pupa of *Phyllognathus dionysius*: **A.** Prepupa; **B.** Male and female pupa; **C.** Pupa (male) in dorsal view; **D.** Pupa (male) ventral view; **E.** Pupa (male) in lateral view.

Figure 5. Morphological characters of pupa of *Phyllognathus dionysius*: **A.** Male pupa head; **B.** Gin traps; **C.** Pupa ventral segment; **D.** Pupal spiracles.

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